UNITED STATES DISTRICT COURT
SOUTHERN DISTRICT OF NEW YORK

JAMES CONTANT, *et al.*, Plaintiffs, v. BANK OF AMERICA CORPORATION, *et al*., Defendants.	Case No. 17-cv-3139-LGS (related to No. 13-cv-7789-LGS)

REPORT OF CAROL L. OSLER, PH.D.
April 5, 2018

INTRODUCTION AND QUALIFICATIONS

1. I am the Martin and Ahuva Gross Professor of Financial Markets and Institutions at the Brandeis International Business School, Brandeis University. I have previously served as Senior Economist for the Federal Reserve Bank of New York Capital Markets Division of Research, and as a Visiting Economist for the Federal Reserve Bank of New York's Foreign Exchange Trading Desk. My educational background includes a B.A. in Economics from Swarthmore College and a Ph.D. in Economics from Princeton University. A current version of my curriculum vitae is attached to this Report as Exhibit A.

2. I have been engaged by Berger & Montague, P.C. ("Class Counsel") to review information and data pertaining to retail and spot FX Instrument prices. Class Counsel have asked me to analyze the pricing mechanisms by which Defendants sell spot FX instruments to retail foreign exchange dealers ("RFEDs") as well as the pricing mechanisms by which RFEDs sell spot FX instruments to retail FX customers, and render an opinion as to: (a) how prices for spot FX instruments sold by RFEDs are determined; (b) whether prices for spot FX instruments sold by Defendants and prices for spot FX instruments sold by RFEDs tend to move together; and (c) whether an anticompetitive overcharge incurred in a sale of a spot FX instrument to an RFED would be passed on to the retail customer where the RFED resells that same spot FX instrument to the retail customer.

3. As discussed below, based on my observation and analysis of the structure of FX trading during the alleged Class Period and the results of various statistical tests using retail spot prices, wholesale spot prices, and benchmark rate prices, I conclude that any anticompetitive overcharge incurred in a sale of a spot FX instrument by a Defendant to an RFED is necessarily passed on to the FX retail customer, i.e., a Plaintiff in this case, where the RFED resells that same spot FX instrument to the FX retail customer.[1] I also conclude that there would have been widespread payment of overcharges across the retail customer Class members, and that given sufficient data from Defendants and the RFEDs, I would be able to specify a model (or models) capable of reliably computing aggregate damages to the Classes.

[1] I understand that Plaintiffs in this case have limited the definitions of the proposed Classes to persons who purchased an FX Instrument from an RFED where the RFED purchased the FX Instrument from a Defendant or co-conspirator. Therefore, to the extent that any RFEDs sold FX Instruments during the Class Period using pricing models that did not follow the Defendant-to-RFED-to-Class member model described herein, those transactions are excluded from the proposed Classes.

ANALYSIS

4. The chain of causation from dealer bank-induced exchange rate distortions to retail forex ("FX") prices is direct, strong, and inevitable. The bid and ask prices on a retail screen are set by a computer program and move one-for-one with dealer bank prices (often referred to as "wholesale prices"). If wholesale prices were distorted by collusion on spreads, collusion on trading at a fix, or other misconduct, then that distortion would be passed on one-for-one to retail prices.

5. According to an academic expert on RFEDs, "Each [RFED] continuously offers bid and ask quotes to its clients, such as the Plaintiffs in this case. The [RFED] is the counterparty on all transactions, that is, it actually trades with clients as opposed to simply matching trades (though over time it can offload these positions to other clients or to the interbank market). …. *Each [RFED] maintains a proprietary algorithm for generating bid and ask quotes that are based on . . . a data feed from the interbank market. …* . Therefore, clients' trading costs are in proportion to the size of the trade and depend on the bid-ask spreads charged [to RFEDs]." (Italics added).[2]

6. As indicated above, an RFED's computer algorithm sets the bid and ask prices in three steps. Step 1: Take in prices from one or more dealer banks as sources of liquidity; Step 2: Identify the highest bid and lowest ask prices among those liquidity-provider prices; Step 3: Set the retail ask price by adding a markup to the wholesale ask; and set the retail bid price by subtracting a markup from the wholesale bid.[3] Depending on the specific RFED, the Step-1 market prices will almost certainly include streaming quotes from one or more Defendant liquidity providers, given the dominance of Defendant banks in the wholesale FX market.

7. Each RFED's pricing algorithm works continuously (in essence, 24/7). Because wholesale prices change at high frequencies, retail prices also change frequently: indeed, on FOREX.com – where prices are posted publicly in real time – prices often change every second.

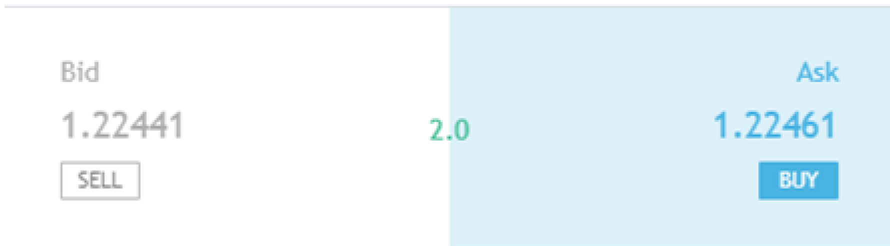
---

[2] Heimer, Rawley Z., and Alp Simsekz (2017). Should Retail Investors' Leverage Be Limited? *NBER Working Papers 24176*, National Bureau of Economic Research, Inc., p. 7.

[3] Equivalently, the retail prices could be said to be calculated by first identifying the wholesale mid-quote and adding (for the ask) or subtracting (for the bid) an appropriate markup spread.

8. Consider the example of Figure 1, where a customer of FOREX.com wants to purchase 100 euros (EUR 100) with U.S. dollars (USD) and FOREX.com is quoting the following bid and ask prices:[4]

Figure 1: Illustrative EUR/USD retail FX prices taken from FOREX.com.



9. In this example, the "**Bid**" price of 1.22441 is the number of USD that FOREX.com is willing to pay to buy one EUR, or equivalently the price at which a retail customer can sell one EUR to FOREX.com. The "**Ask**" price of 1.22461 is the number of USD that FOREX.com is willing to accept in exchange for one EUR, or equivalently the price at which a retail customer can buy one EUR from FOREX.com. The retail **bid-ask spread** (or "spread") quoted by Forex.com is 0.0002 or 2.0 "**pips**." The retail market mid-quote at this moment, 1.22451, would be essentially the same as the wholesale market mid-quote, as shown by the statistical analysis below in Paragraphs 15 to 25. The wholesale bid-ask spread would normally be smaller than the retail spread; with a wholesale spread of 1 pip, the wholesale bid and ask would be 1.22446 and 1.22456.

10. It is my understanding that Plaintiffs allege in this case that FX dealer (i.e., Defendant) misconduct affected prices quoted by those Defendant banks to their customers, including RFEDs. Distortions in prices quoted by Defendant banks to customers prices due to Defendants' alleged price manipulation would have been passed through essentially one-for-one to retail prices because FX retail quotes are determined as a markup over the prices that dealer banks (including Defendants) stream to their active customers (including RFEDs).

11. To illustrate the chain of causation, suppose prices on the electronic dealer trading platform Electronic Broking Services ("EBS") are distorted upwards at the WM/Reuters London

[4] These FOREX.com images are screenshots from FOREX.com's online trading platform. *See* https://webtrading.forex.com (last accessed Mar. 20, 2018).

4 pm Fix and for some time thereafter. Within a tiny fraction of a second, each distorted EBS price will influence the Step-1 prices used in the RFED pricing algorithms, including streaming prices from the liquidity provider Defendants. These distorted prices will influence the highest dealer bid and lowest dealer ask prices identified by the RFED pricing algorithms in Step-2. Finally, the distortions will be passed through directly in Step 3 when the RFED pricing algorithm adds a markup (for the ask) and subtracts a markup (for the bid) to generate the RFED's own bid and ask quotes for clients which include the Plaintiffs. Because the distorted bid and ask quotes from the liquidity providers are incorporated into the RFED bid and ask quotes, any price distortions at the liquidity provider level are passed down to the retail customer at the RFED level.

12. An RFED cannot afford to let its quotes deviate substantially from the market's contemporaneous wholesale quotes. The dangers of failing to move RFED quotes closely with wholesale prices can be illustrated by extending the earlier example, in which the retail bid price was 1.22441 and the retail ask was 1.22461. Suppose the streaming quotes from a liquidity provider shift from 1.22446 (bid) and 1.22456 (ask) to 1.22466 (bid) and 1.24476 (ask). An institutional customer could buy EUR 10,000 at 1.22461 from the RFED and sell those euros to another dealer at 1.22466, earning USD 0.00005 per EUR.[5] In essence, the customer perceives an opportunity to make arbitrage profits at the expense of the dealers. The RFED will then take a loss when restoring its inventory because it must buy the euros from the liquidity provider at 1.24476 even though it sold them at 1.22461. The RFED's loss would be USD 0.00015 per EUR (0.00015 = 1.22461 – 1.24476). This example helps to explain why, in order to eliminate the risk of taking such a loss, RFEDs employ pricing algorithms that pass on the prices to their retail customers, such as the Plaintiffs, at which they purchase FX directly from the Defendants.

13. RFEDs thus have a strong incentive to move their quotes closely with wholesale prices, and no incentive not to do so. In other product markets, retail vendors of goods and services often have strong incentives to stabilize prices around certain price points. Prices ending in the

[5] High-frequency trading firms are noted for making small profits on a high volume of trades. "Often the sum of money on an individual stock may appear to be very small - say, a few cents profit here or there. But with the volumes ranging in the millions and higher, a few cents profit on each stock can amount to a lot overall." Chimbelu, Chiponda. "Twitter's hash crash: Social media and the financial markets." *Deutsche Welle* (*dw.com*), 5 December, 2013. http://www.dw.com/en/twitters-hash-crash-social-media-and-the-financial-markets/a-16838715

number 9, for example, typically attract more buyers than prices ending in other numbers, an effect that can work even when the other prices are lower.[6] A clothing or home-goods retailer may therefore find that setting a price ending in 9 not only increases profits per item but also increases sales. Even if production costs increase there may be a sufficient profit cushion, and sufficient incentive in terms of the sales response to a price ending in 9, to leave the retail price unchanged. In such cases, the retailer may "absorb" an anticompetitive overcharge incurred as a result of price-fixing at the wholesale level, rather than pass that overcharge on to the retail customer in the form of a price increase. There are no such incentives to set price points for retail FX quotes, however. Therefore, any distortions in wholesale pricing are fully incorporated into RFED pricing.

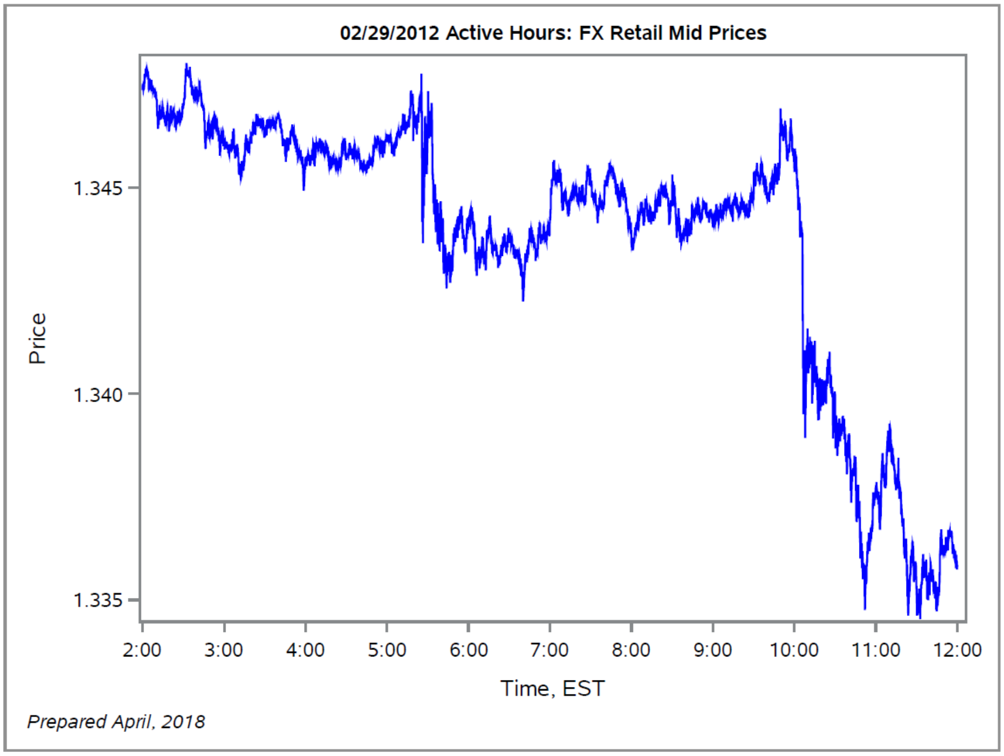
14. Retail bid-ask spreads are so tight that even slight changes in wholesale prices necessitate some adjustment in retail quotes. Some RFEDs, for example, set retail spreads at an average half-pip markup over wholesale prices.[7] This is far smaller than many market responses to macroeconomic news surprises. Figure 2 depicts an extreme example of such a surprise is the 60-odd-pip drop at 10:00 am on February 29, 2012 (in response to a surprisingly strong estimate of US GDP growth during 2011:Q4 released at 10:00 am). Retail spreads are also far smaller than the 10- to 15-pip wholesale price moves common during the quarter hour before the WM/Reuters 4 pm Fix[8] on end-month dates, as shown in Figure 3. If an RFED were to hold its prices stable during even a minute at such volatile times, it would soon find itself taking losses as customers exploited arbitrage opportunities.

[6] Morad, Renee. "7 Pricing Tricks That Make You Spend More." *CBSNews.com*, 12 October, 2015. https://www.cbsnews.com/media/7-pricing-tricks-that-make-you-spend-more/2/

[7] http://www.gurutrade.com/forex-spreads/

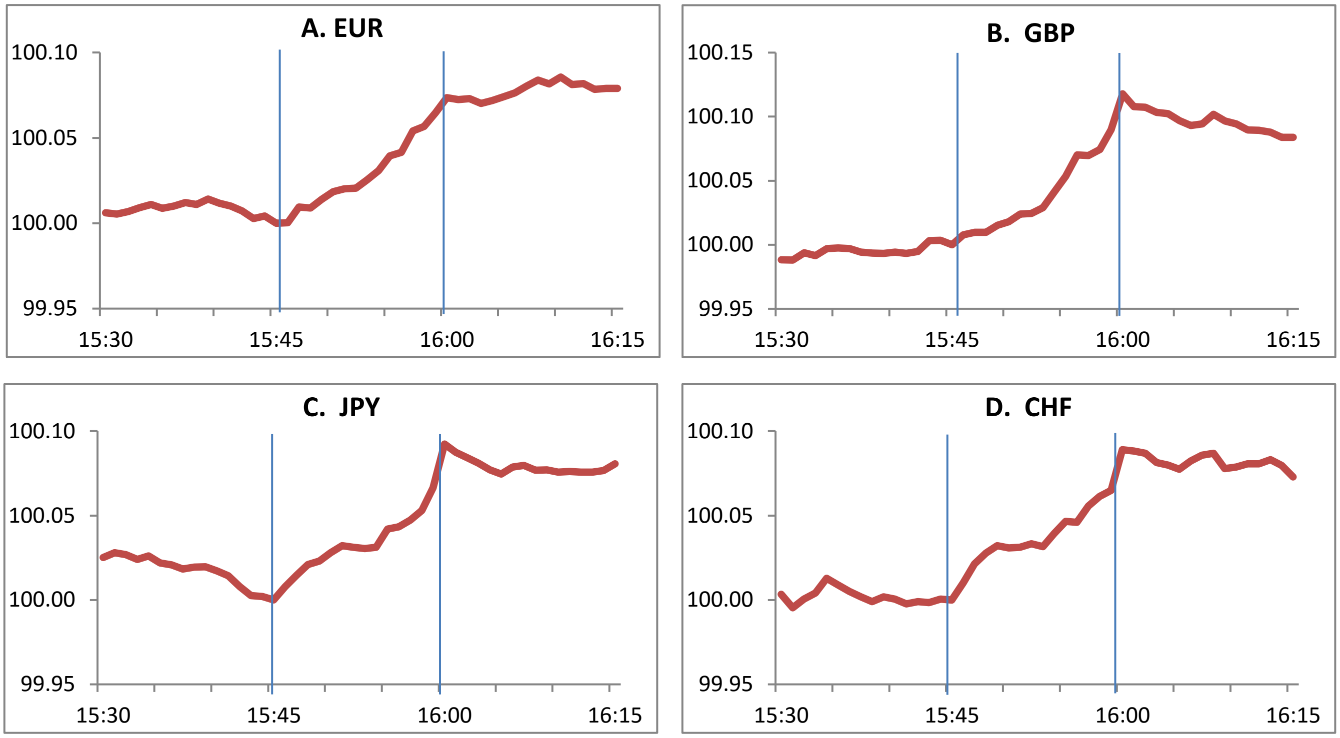
[8] The WM/Reuters Closing Spot Rates, known as the "WM/Reuters Fix," is set at 4:00 p.m. London time (11:00 a.m. New York time). The WM/Reuters Fix is widely used because it is set when the FX market is most liquid. WM/Reuters calculates the 4:00 p.m. Fix based on actual bids and offers placed on certain electronic trading systems during a one-minute window ("the fix period"). The fix period begins 30 seconds before 4:00 p.m. London time and ends 30 seconds after. WM/Reuters uses bids and offers placed on the Currenex, Reuters Dealing 3000, and Electronic Broking Services ("EBS") electronic trading systems. EBS is a wholesale electronic trading platform used to trade FX with market making banks.

Figure 2: FX EUR/USD prices on 29 February, 2012.[9]



[9] Prices taken from FOREX.com, the largest RFED.

Figure 3: Average price paths around the WM/Reuters 4 pm Fix for major currencies vs. USD.
End-month dates, January 2008 through June 2013. Minute-by-minute quote data from the Reuters Tick History database. On each date the price is indexed to 100 at 3:45. Path is inverted for days on which the fix price is below the 3:45 price. Price path shown is the average of these index values.



15. The tight links from wholesale to retail prices can be readily documented with empirical analysis. For this analysis I use wholesale prices from Reuters Tick History dataset and retail prices from FOREX.com, the world's largest RFED (with daily trading volume of $15.5 billion).[10] The Reuters "Tick History" data comprises the best-available quotes from the major dealer-bank trading platforms—including EBS, Reuters Matching, Reuters Dealing, and others—updated at high frequencies. Because Defendants collectively dominate the FX dealer market, a substantial portion of those quotes are direct quotes from Defendants.

16. The FOREX.com data include bid and ask price observations recorded many times per minute during active trading hours. For every new FOREX.com quote during February 2012, I select a time-matched Reuters Tick History price. I performed the specific analyses in this

[10] Fair Reporters. Largest Forex Brokers by Volume in 2017, April 9, 2017, http://fairreporters.net/economy/largest-forex-brokers-by-volume-in-2015/ (Accessed 3/25/2018).

Report following the Court's March 15, 2018, Opinion in this case. With more time, I could perform move extensive comparisons for the entire Class Period alleged by the Plaintiffs.

17. Figures 4A and 4B show visually the extent to which Reuters Tick History prices and FOREX.com quotes track each other by depicting both price series during two full trading days during the Class Period: Wednesday, February 22 and Wednesday, February 29, 2012. I focus on the hours during which prices are updated most frequently, 7:00 am to 5:00 pm London time or equivalently 2:00 am to noon, EST ("**active trading hours**"). The figures show that the retail and wholesale price series are virtually indistinguishable on the graph even when prices are changing rapidly – for example, at 10:00 am on February 29. The blue oval on the right in Figure 4A demonstrates the price movements around the time of the WM/Reuters Fix, and the blue oval to the left in Figure 4A shows the price movements around the time of the European Central Bank ("ECB") Fix.[11] The blue oval in Figure 4B highlights the period in which prices moved rapidly in response to news about US GDP, as described in Paragraph 14. Throughout these trading days, including all three of the volatile periods just mentioned, the two prices are so nearly perfectly correlated for the entire period that in just a few instances does the blue line appear as a speck where it is not otherwise completely obscured by the gold Reuters line. During February 2012, the average absolute gap between the retail and wholesale mid-quotes is tiny, at EUR 0.0000694 USD, or roughly one-half of a pip.[12] A gap this of size would rarely, if ever, create arbitrage opportunities for customers.

[11] The ECB reference rate provides FX spot rate Fixes for currency pairs that are traded against the euro. After the WM/Reuters Fix, the ECB Fixis the second-most widely used global FX benchmark rate.

[12] This calculation relied on 501,445 observations.

Figure 4: Retail (FOREX.com) and wholesale (Reuters Tick History) EUR/USD Prices during Active Trading on Two Days in February 2012.

4A: Wednesday, February 22, 2012.

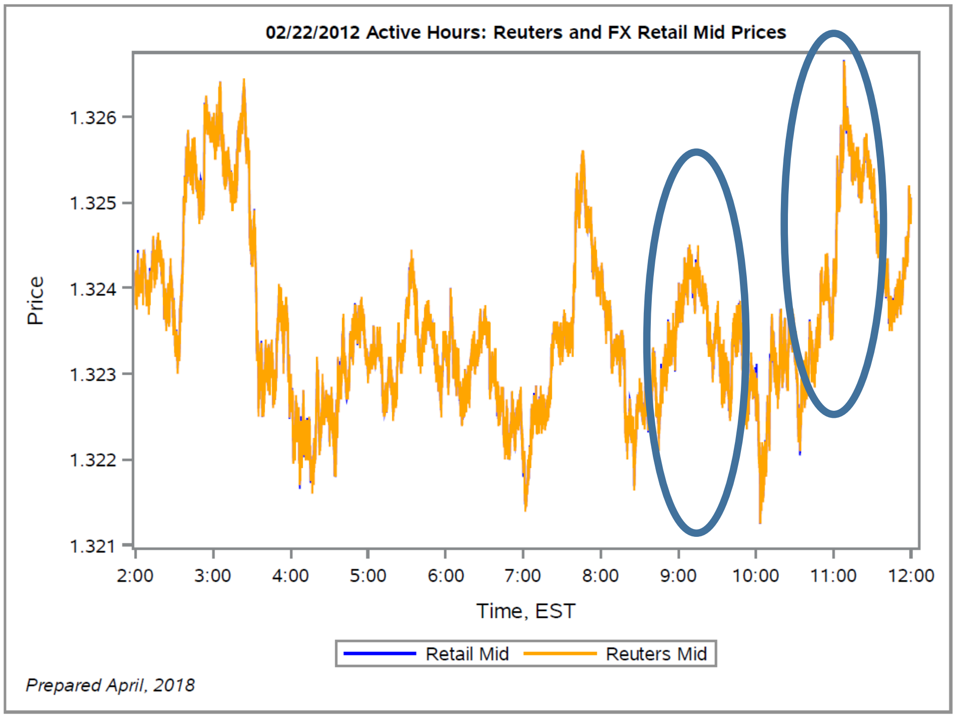
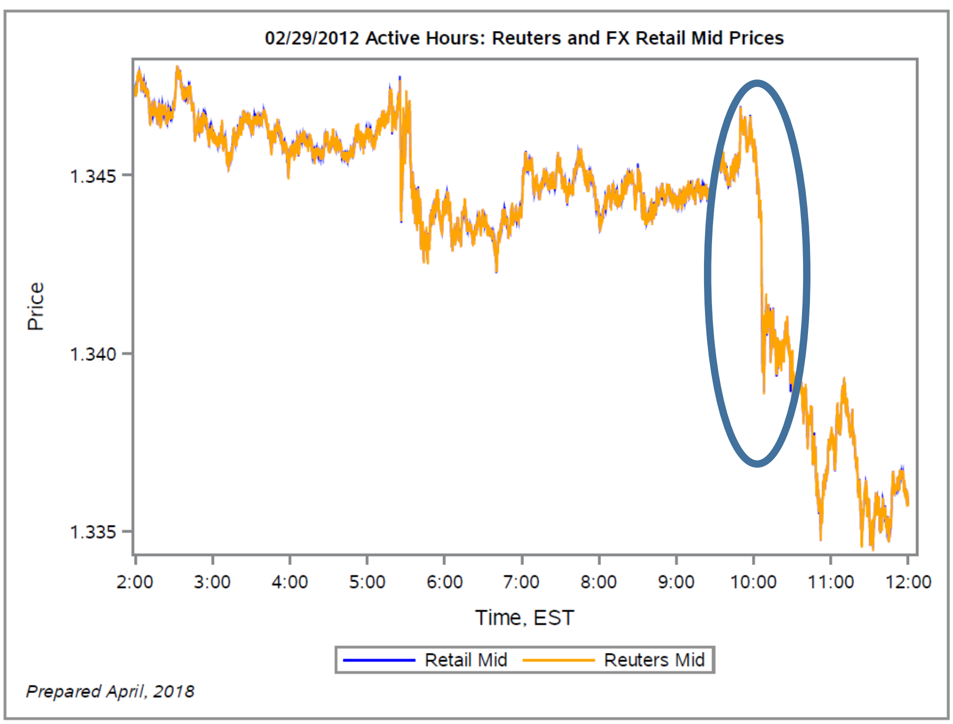


Figure 4B: Wednesday, February 29, 2012.



18. Figures 5A and 5B further confirm that retail prices closely track wholesale prices even when prices are highly volatile. Both Figures focus on the interval from 12:45 pm to 5:00 pm London time, an interval that includes both the ECB Fix (at 2:15 p.m. CET or 9:15 a.m. EST) and WM/Reuters London 4 pm Fix (at 4:00 p.m. London time or 11:00 a.m. EST). I select two particularly volatile dates for this comparison: February 15, 2012, and February 21, 2012. Consistent with earlier Figures, the two wholesale (gold) and retail (blue) price series are virtually indistinguishable, despite the volatility.

Figure 5: Retail (FOREX.com) and wholesale (Reuters Tick History) EUR/USD prices around the ECB and WM/Reuters Fixes.

Figure 5A. Wednesday, February 15, 2012

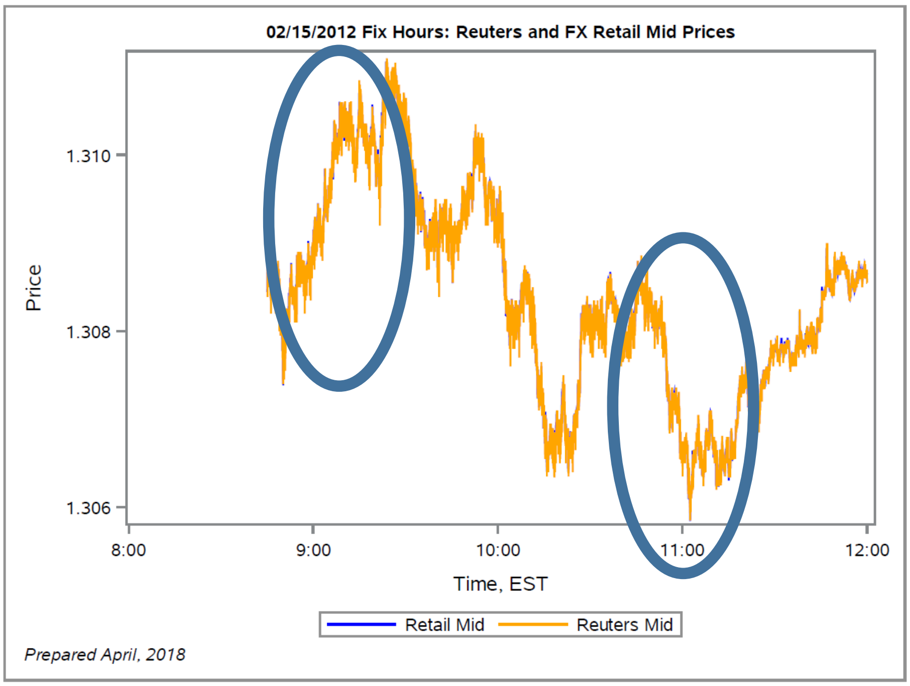
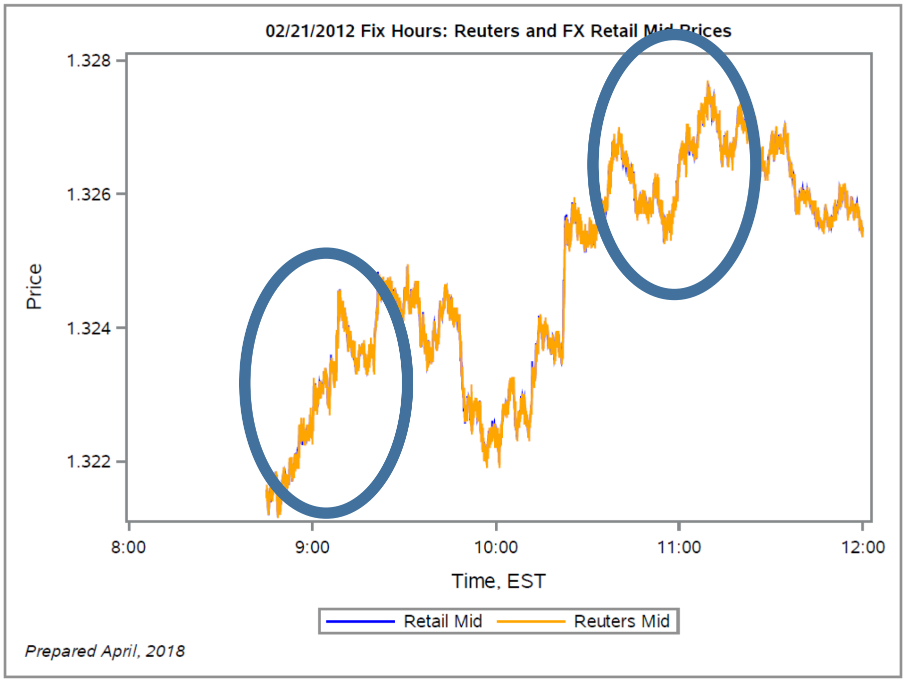
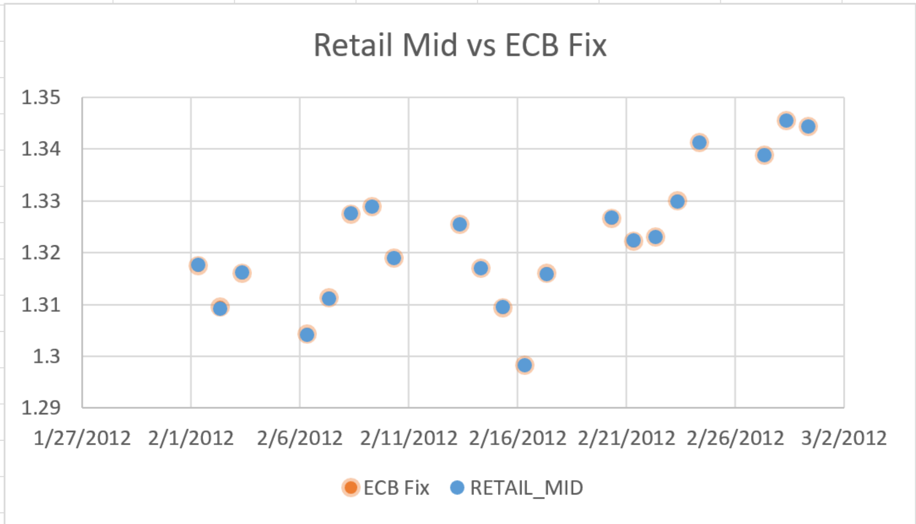


Figure 5B. Tuesday, February 21, 2012.



19. The extent to which retail and wholesale prices match at the major fixes is important, given the extent of collusion-induced distortion at those times. Figure 6 shows that the retail mid-quotes at the time of the ECB Fix – 2:15 CET (8:15 EST) – are essentially identical to ECB Fix prices. To quantify the extent to which these prices match I calculated the correlation between the two. A correlation coefficient measures the extent to which two variables move in parallel. At its maximum possible value of +1.00 the correlation coefficient would indicate that the two variables move exactly perfectly in parallel; at its minimum possible value of -1.00 the correlation coefficient would indicate that two variables move perfectly inversely to one another. In this case the correlation coefficient is extremely high, at 0.99996, and highly statistically significant (the probability that the true value is zero is below 0.0001). Correlation coefficients are rarely reported with more precision than is offered by two decimal places, by which standard this correlation is exactly 1.00. In short, this correlation coefficient indicates that retail prices at fix times almost-exactly match recorded Fix prices. If Fix prices were distorted by misconduct among Defendant banks, the distortion would be passed through to retail prices essentially one-for-one.

Figure 6: EUR/USD ECB Fix prices and retail mid-quotes at the same time, 2:15 CET.



20. I also calculated the raw correlation between FOREX.com prices and prices in the Reuters Tick History. I select the time-matched retail and wholesale prices for every minute on each of the 21 business days in February 2012, during active trading hours (12,621 observations). The correlation between wholesale and retail mid-quotes is extraordinarily high, at 0.99997, or 1.00 at standard levels of precision, and like the correlation with Fix prices it is highly statistically significant.

21. I finish analyzing the links between wholesale and retail FX prices by applying a statistical procedure known as a "**regression**" that can rigorously disentangle complex and multi-faceted relationships.[13] Regression analysis has proved immensely useful throughout the sciences. It is now a standard part of the professional analytical toolkit in all major social science disciplines.

22. I regress minute-by-minute proportionate changes in FOREX.com mid-quotes (*Prop.Change.Retail*) on minute-by-minute proportionate changes in Reuters Tick History mid-quotes (*Prop.Change.Wholesale*) using data from the active trading hours of 7:00 to 17:00 London time (2:00 am – noon, EST) during February 2012. My regression model is:

$$Prop.Change.Retail_m = \boldsymbol{\alpha} + \boldsymbol{\beta} * Prop.Change.Wholesale_m + \varepsilon_m.$$

[13] Green, William H. (2008). *Econometric Analysis*: *Sixth Edition* (Pearson Education: NJ), pp. 8 – 19.

A given minute is denoted "*m*." $Prop.Change.Retail_m$ is the FOREX.com price change from minute *m*-1 to minute *m* divided by *m*-1 FOREX.com price:

$$Prop.Change.Retail_m = (PRetail_m - PRetail_{m-1})/PRetail_{m-1}.$$

$Prop.Change.Wholesale_m$ is calculated similarly but using Reuters Tick History prices. "Ordinary Least Squares," a simple and common regression methodology, is suitable for estimating α and β in this context.

23. I use this regression to examine three implications of the hypothesis that retail and wholesale prices are almost identical and move almost perfectly in parallel.

(i) If retail and wholesale prices are almost-identical, the constant term, α, would be roughly zero. Otherwise retail prices would have a tendency to move progressively far away from wholesale prices. The "closeness" of the estimated value of α to zero can be evaluated using a standard statistical test known as a *t*-test.[14]

(ii) If retail and wholesale prices move almost perfectly in parallel the coefficient on wholesale price movements, β, will be close to one. That is, every 1-basis-point move in wholesale prices would be matched by a roughly-1- basis-point move in retail prices. The closeness of the estimated value of β to one can be evaluated using *t*-tests.

(iii) If retail and wholesale prices are almost identical and move almost perfectly in parallel, $\alpha + \beta * Prop.Change.Wholesale_m$ will account for or "explain" most of the retail price movement in that minute, $Prop.Change.Retail_m$. The term ε, which is called the "regression residual," can be interpreted as the portion of a given retail price move that is not accounted for by the constant and the wholesale price move. The stronger the relation between wholesale and retail price moves the smaller these residuals will be. A regression that produces small residuals is said to have high "explanatory power." Explanatory power is measured as the regression's "***R*-squared**," a statistic that ranges from 0.0 (zero explanatory power or, in this case, no

[14] A *t*-statistic is the ratio of (i) the absolute difference between the estimated coefficient and its theoretical value to (ii) the inevitable statistical uncertainty surrounding α's estimated value. That uncertainty is measured as α's estimated standard error, which I calculate using "robust" standard errors, as introduced in White, Halbert (1980). "A Heteroscedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroscedasticity" *Econometrica*. 48(4): 817–838. Given the high number of observations in our regression (12.621), a *t*-statistic below 1.96 would be sufficient to conclude that there is no difference between α's estimated and zero.

link at all between retail and wholesale prices) to 1.0 (100% explanatory power or, in this case, wholesale price moves are the only thing that drive retail price moves and all residuals are zero).

24. The regression results shown below confirm that retail prices move almost perfectly in parallel with wholesale prices.

$$Prop.Change.Retail_m = \quad \boldsymbol{\alpha} \quad + \quad \boldsymbol{\beta} \quad * \; Prop.Change.Wholesale_m + \varepsilon_m \quad .$$

$$Prop.Change.Retail_m = \underset{(t=0.29)}{\mathbf{0.00000025}} \quad + \quad \underset{(t=143.21)}{\mathbf{0.86}} * Prop.Change.Wholesale_m + \varepsilon_m$$

R-squared: 0.80.

25. I examine the implications of these results for the strength of the links between retail and wholesale prices using the three criteria listed in Paragraph 22.

(i) The estimated value of the constant term, α, is tiny, consistent with the hypothesis that retail and wholesale prices move almost-perfectly-in-parallel. Because the *t*-statistic is below the "critical value" of 1.96, one can reasonably conclude that α is in truth zero (the *t*-statistic of 0.29 is below the critical value of 1.96). This is essential for documenting a link between retail and wholesale prices because if α is not zero then retail and wholesale prices will move progressively farther and farther away from each other.

(ii) The estimated value of the slope coefficient, β, is close to one as predicted under almost-perfectly-parallel price movements. This coefficient is definitely greater than zero, as indicated by the fact that the t-statistic of 143.21 exceeds the critical value of 1.96. To test whether β is exactly equal to one or just a bit below it I use a second t-test. In this case the t-statistic is 23.33, which again exceeds the critical value of 1.96. This indicates that retail prices on a minute-by-minute basis move almost-but-not-quite perfectly with wholesale prices. As noted earlier, this is not surprising even given very-tight links from wholesale to retail prices.

(iii) Also consistent with consistent with the hypothesis of almost-perfectly-parallel price movements is the finding that wholesale price changes account for the vast bulk of retail price changes: equivalently, very little of a given retail price move is unrelated

to the contemporaneous wholesale price move so the regression has extremely high explanatory power. The regression's *R*-squared statistic is 0.80, a figure that is high by any standards within economics and finance and that is especially high for the analysis of financial-price changes. Attempts to explain financial price changes using regression analysis are notorious for having *R*-squared values below 0.05, and those values are often below 0.01. Another useful benchmark for comparison is a seminal paper on exchange rates widely recognized for its extraordinarily high *R*-squared values. The 0.80 *R*-squared in our retail-wholesale regression far exceeds those *R*-squared values, which are at most 0.46 for dollar-yen to 0.64 for dollar-Deutschemark.[15]

26. In short, these data confirm in three ways that retail (Forex.com) and wholesale (Reuters Tick History) FX prices move almost-perfectly-in-parallel: the estimated value of α is approximately zero, the estimated value of β is close to one, and the regression's explanatory power (*R*-squared) is extraordinarily high.

CONCLUSION

27. Based on the foregoing analysis of RFED pricing, including various statistical tests, I believe that the price that an RFED charges its FX retail customers, such as the Plaintiffs in this case, for an FX Instrument is an algorithmic function of the price that the liquidity providers, i.e., the Defendants in this case, charge the RFED for the FX Instrument, plus a retail markup charged by the RFED. RFED prices are updated in real time, meaning that any distortions in liquidity provider prices are almost instantaneously reflected in RFED prices. This pricing mechanism means that any anticompetitive overcharge incurred in a sale of a spot FX instrument by a Defendant to an RFED is necessarily passed on to the FX retail customer, i.e., a Plaintiff in this case, where the RFED resells that same spot FX instrument to the FX retail customer.

28. That conclusion is confirmed by my analysis of the trading data, as discussed in this Report. I compare prices at FOREX.com, the largest RFED, with wholesale prices from the Reuters Tick History database. I show that retail prices are essentially identical to contemporaneous wholesale prices, and that these tight links apply equally to periods of high

[15] Evans, Martin, and Richard K. Lyons (2002). Order Flow and Exchange Rate Dynamics. *Journal of Political Economy*, 110(1).

volatility such as fixes and news events. Distortions in wholesale prices resulting from Defendants' misconduct would therefore have been passed through one-for-one to the FX retail prices paid by the Plaintiffs.

29. Based on my findings, it is clear there would have been widespread payment of overcharges across the retail customer Class members throughout the Class Period. Given sufficient data from Defendants and the RFEDs, I would be able to specify a model (or models) capable of reliably computing aggregate damages to the Classes.

30. I apply standard statistical procedures to show that that retail FX prices have an essentially perfect correlation with wholesale FX prices. Finally, I conduct a regression analysis in which minute-by-minute percentage price changes on FOREX.com are related to contemporaneous minute-by-minute percentage price changes in the Reuters data. The results confirm once again that changes in wholesale FX prices are matched by near-equivalent changes in FX prices. These results confirm my findings that retail FX prices move in near-perfect parallel with wholesale FX prices.

31. In sum, based on my observation and analysis of data for the alleged Class Period in the case and the results of various statistical analyses, I conclude that any anticompetitive overcharge incurred in a sale of a spot FX instrument by a Defendant to an RFED is necessarily passed on to the FX retail customer, i.e., a Plaintiff in this case, where the RFED resells that same spot FX instrument to the FX retail customer.

Dated: April 5, 2018.

Dr. Carol L. Osler

Exhibit A

Carol Osler, Ph.D.
Professor, Brandeis International Business School
Brandeis University
415 South Street
Waltham MA
Cell: 774-270-1430
cosler@brandeis.edu

Brandeis International Business School
cosler@brandeis.edu
Brandeis University (781) 736-4826
Waltham, MA 02454 Homepage: http://people.brandeis.edu/~cosler/

BIO/Summary

Carol Osler, Ph.D. is the Martin and Ahuva Gross Professor of Financial Markets and Institutions at the International Business School of Brandeis University. Dr. Osler's research focuses on exchange rates and foreign exchange trading. Dr. Osler's courses cover financial market structure and the trading process as well as applied macroeconomic analysis. Dr. Osler's legal consulting engagements have involved the foreign exchange trading of global custody banks as well as dealer trading around the London fixing in foreign exchange.

Dr. Osler previously served as Research Economist at the Federal Reserve Bank of New York. Dr. Osler has also taught at the Tuck School of Business at Dartmouth College, the Kellogg School of Management at Northwestern University, and Columbia University.

EDUCATION

Princeton University, Princeton, NJ. MA Economics, 1983. Ph.D. Economics, 1987
Fields of concentration: International economics, Financial economics, Monetary economics

Swarthmore College, Swarthmore, PA. B.A. Economics, 1980

PROFESSIONAL EXPERIENCE

EXPERT RETENTIONS

2018	*James Contant, et al., vs. Bank of America Corporation, et al.* US District Court, Southern District of New York
2018	*Axiom Investment Advisors, L.L.C. vs. Deutsche Bank AG*, US District Court, Southern District of New York
2017-2018	*Julius di Filippo and David Caron v. Bank of Nova Scotia et al., Defendants*, Ontario Superior Court of Justice
2016-2017	*Chris Staines v. Royal Bank of Canada et al., Defendants*, Ontario Superior Court of Justice
2015-2016	U.S. Department of Justice action on price-fixing conspiracy in FX markets

2014 Lovell Stewart Halebian Jacobson LLP. Preliminary work towards class-action complaint on price-fixing conspiracy in FX markets

2011-2012 Consultant for Charles River Associates in their support of State Street Bank in *People of the State of California v. State Street et al., Superior Court of the State of California County of Sacramento.*

ACADEMIC ENGAGEMENTS

PRESENT: Martin and Ahuva Gross Professor of Financial Markets and Institutions, Brandeis International Business School, Brandeis University

2008-2015 Director, Lemberg Masters Program in International Economics and Finance, Brandeis International Business School

2007-2008 Acting Director, Ph.D. Program, Brandeis International Business School

2002-2013 Associate Professor of Finance and Economics, Brandeis International Business School

1991-2002 Federal Reserve Bank of New York. Capital Markets Division of Research and Market Analysis Group. Senior Economist

1994 Visiting Economist, Foreign Exchange Trading Desk, Federal Reserve Bank of New York

1993-1996 Columbia University, Adjunct Assistant Professor of Economics.

1990-1991 Kellogg School of Management, Visiting Assistant Professor of Finance.

1988 NBER Ford Foundation Fellow

1985-1991 Assistant Professor, Amos Tuck School of Business Administration, Dartmouth College.

RESEARCH

PEER REVIEWED PUBLICATIONS

"The Market Microstructure Approach to Foreign Exchange: Looking Back and Looking Forward," joint with Michael King and Dagfinn Rime (2013). *Journal of International Money and Finance* 38 (November): 95-119.

"Currency Market Microstructure and the Profitability of Currency Trading" (2012). *Annual Review of Financial Economics* 4: 469-495.

"Noise Trading and Illusory Correlations in US Equity Markets," joint with Jennifer Bender and David Simon (2012). *Review of Finance* 17(2): 625-652.

"Survival of Overconfidence in Currency Markets," joint with Thomas Oberlechner (2012). *Journal of Financial and Quantitative Analysis* 47(1): 92-113.

"Price Discovery in Currency Markets," joint with Alexander Mende and Lukas Menkhoff (2011). *Journal of International Money and Finance* 30 (8): 1696-1718.

"Extreme Returns: The Case of Currencies," joint with Tanseli Savaser (2011). *Journal of Banking and Finance* **35**: 2868-2880

"Limit-Order Submission Strategies under Asymmetric Information." Joint with Lukas Menkhoff and Maik Schmeling (2010). *Journal of Banking and Finance* 34(11): 2665-2677.

"Macro Lessons from Microstructure" (2006). *International Journal of Finance and Economics* 11: 55-80.

“Stop-Loss Orders and Price Cascades in Currency Markets” (2005). *Journal of International Money and Finance* 24: 219-241.
"Currency Orders and Exchange-Rate Dynamics: Explaining the Success of Technical Analysis" (2003). *Journal of Finance* 58: 1791-1819.
"The Changing Landscape of the Financial Services Industry: What Lies Ahead?" (2000). *Economic Policy Review* 6 no. 4: 39-54. www.ny.frb.org/rmaghome/econ_pol/900lown.pdf
"Support for Resistance: Technical Analysis and Intraday Exchange Rates" (2000). *Economic Policy Review* 6, no. 2: 53-67. http://www.newyorkfed.org/research/epr/00v06n2/0007osle.html
"Rapidly Rising Corporate Debt: Are Firms Now Vulnerable to an Economic Slowdown?" (2000). *Current Issues in Economics and Finance* 6, no. 7: 1-6.
"Rational Speculators and Exchange Rate Volatility" with John Carlson (2000). *European Economic Review* 44: 231-253.
"Methodical Madness: Technical Analysis and the Irrationality of Exchange-Rate Forecasts," with Kevin Chang (1999). *Economic Journal* 109: 636-661.
"Second District House Prices: Why So Weak in the 1990s?" joint with Matthew Higgins and Anjeli Sridhar (1999). Federal Reserve Bank of New York *Current Issues in Economics and Finance* 5(January).
"Short-Term Speculators and the Puzzling Behavior of Exchange Rates" (1998). *Journal of International Economics* 43(1): 37-58.
"Asset Market Hangovers and Economic Growth: U.S. Housing Markets," joint with Matthew Higgins (1998). In: *The Role of Asset Prices in the Formulation of Monetary Policy*, BIS Conference Papers Vol. 5 (Bank for International Settlements, Basle).
"Asset Market Hangovers and Economic Growth: The OECD During 1984-1993," join with Matthew Higgins (1997). *Oxford Review of Economic Policy* 13(3): 110-34.
"Charting : Chaos Theory in Disguise?" joint with William Clyde (1997). *Journal of Futures Markets* 17(August): 489-514.
"Exchange Rate Dynamics and Speculators' Horizons" (1995). *Journal of International Money and Finance* 14: 695-719.
"The Credit Slowdown Abroad," joint with S. Hickok (1994). In: *Studies on Causes and Consequences of the 1989-92 Credit Slowdown* (Federal Reserve Bank of New York): 429-73.
"High Real Interest Rates and Investment in the 1990s" (1994). Federal Reserve Bank of New York *Quarterly Review* 19(1): 38-44.
"Interest Rate Term Premiums and the Failure of Uncovered Interest Rate Parity" (1992). *Journal of International Financial Markets, Institutions and Money* 2(2): 1-26.
"Factor Prices Under Integrated Markets for Risky Capital," (1991). *European Economic Review* 35: 1311-40.
"Explaining the Absence of International Factor-Price Convergence" (1991). *Journal of International Money and Finance* 10: 89-107.
"Optimal Growth Under Uncertainty" (1991). *Economic Letters* 36: 31-35.

OTHER PUBLICATIONS

“Greece Illustrates the Importance of Staying Within Economic Limits” (2015). *European Politics and Policy* (London School of Economics) September 1.

http://blogs.lse.ac.uk/europpblog/2015/09/01/greece-illustrates-the-importance-of-staying-within-economic-limits/

"Reading Between the Lines of Greece's Bailout: Debt Relief is Inevitable – Just Not Yet" (2015). *The Conversation*. July 20. http://theconversation.com/reading-between-the-lines-of-greeces-bailout-debt-relief-is-inevitable-just-not-yet-44744

"The Fix Is In" (2014). *The Conversation*. November 13. http://theconversation.com/the-fix-is-in-how-banks-allegedly-rigged-the-us-5-3-trillion-foreign-exchange-market-33828.

"Foreign Exchange Market Structure, Players, and Evolution" (2012), with Michael King and Dagfinn Rime. In: James, J., Marsh, I., Sarno, L. (Eds), *Handbook of Exchange Rates*. (Wiley and Sons: New York and London).

"The Microstructure of Currency Markets: Market Microstructure in Emerging and Developed Markets" (2013), with Xuhang Wang. Chapter 5 in: Ed. Kent Baker and Halil Kiymaz, Eds. (John Wiley, Inc.: New York and London).

"Foreign Exchange Microstructure: A Survey" (2009). *Encyclopedia of Complexity and System Science,* Robert A. Meyers, Ed (Springer: New York).

"The Exchange Rate in a Behavioral Finance Framework" (2007). Book Review: *Journal of International Economics* 72: 265-270.

"Is More Always Better? Head-and-Shoulders and Filter Rules in Foreign Exchange Markets," joint with P.W. Kevin Chang (1998). In: E. Acar and S. Satchell, eds., *Advanced Trading Strategies and Tactics.* (Irwin-Probus: London).

WORKING PAPERS

"Shrouding and the Foreign Exchange Trades of Global Custody Banks." (with Tanseli Savaser). Working Papers 118, Brandeis University, Department of Economics and International Business School.

"Price Discrimination in OTC Markets." (with Geir Bjønnes and Neophytos Kathitziotis). January, 2017.

"Dealer Trading at the Fix" (with: Alasdair Turnbull). June, 2017. Working Papers 101R, Brandeis University, Department of Economics and International Business School, revised.

Depth and Information in the Foreign Exchange Limit Order Book: A Nonlinear Approach" (with Ly Tran). February, 2015.

"Short-Run Exchange-Rate Dynamics: Theory and Evidence," with John A. Carlson and Christian Dahl.

WORK IN PROGRESS

"Explaining the Intraday Behavior of Spreads in the Foreign Exchange Interdealer Market," joint with David Simon and Shuran Zhang

"Hedge Funds and the Origins of Private Information in the Foreign Exchange Market" Joint with Vitaliy Vandrovych.

OTHER ACADEMIC ENGAGEMENTS

THESIS ADVISING

Current Ph.D.
Shuran Zhang (Chair)
Neophitos Kathitziotis (Hamburg Univ.)

Completed Ph.D., Chair
Ly Tran
Rawley Heimer
David Simon
Rimma Yusim Sherman
Vitaliy Vandrovych
Prasandjeet (Vinay) Nundlall
Tanseli Savaser
Jennifer Chu Bender

Completed Masters
Olzas Kuramazov
Damir Ćosić

Completed Ph.D., Committee
Henok Tewolde
Xia Meng
Tyler Hul
Gotham George
Ritti Bumiputra
Eskandar (Sandro) Tooma
Siri Valseth (Norwegian Schl.Mgmt.)
Kjell Jorgenson (Norwegian Schl.Mgmt.)
Ma Gang
Heidi Zhao

TEACHING

Courses taught since 2002
- Ph.D. Financial Market Microstructure (Norwegian School of Management)
- Applied International Macroeconomics (IBS)
- Trading and Exchanges (IBS)
- Central Banking (IBS)
- Accelerated Financial Theory (IBS)
- Ph.D. International Macro (IBS)

Past teaching expertise
- International Capital Markets (Tuck, Kellogg)
- Bank Management (Tuck)
- Money and Banking (Columbia Undergraduate)
- Macroeconomics (Tuck)
- International Finance (Columbia Undergraduate Economics and Columbia SIPA)

FELLOWSHIPS AND AWARDS

Martin and Ahuva Gross Chaired Professorship in Financial Markets and Institutions

Market Technicians Association, Inc., Recognition Award for the Teaching of Technical Analysis in Academia.

Brandeis University International Business School Teaching Award, 2008.

First Prize, Academic Papers Competition, Investors' Forum, December, 1996, for "Rational Speculators and Exchange Rate Volatility" (with John Carlson).

Faculty Research Fellow, National Bureau of Economic Research, 1987-1991.

Ford Foundation Scholar, National Bureau of Economic Research, Fall 1988.

REFEREE

Associate Editor, Journal of International Financial Markets, Institutions, and Money.
Associate Editor, International Journal of Finance and Economics
Ad hoc referee: Review of Financial Studies, Journal of Economic Literature, NSF, Journal of Finance, Journal of Financial Markets, Journal of Financial and Quantitative Analysis, Journal of Money, Credit, and Banking, International Economic Review, European Economic Review, Journal of International Economics, Journal of Development Economics, Journal of Financial Management, IMF Staff Papers, Science, Review of Economics and Statistics, Journal of International Money and Finance, Journal of Economic Behavior and Organizations, European Journal of Finance, Journal of Empirical Finance, Canadian Journal of Economics, Journal of Financial Services Research, Journal of Economics and Business, Journal of Macroeconomics, Journal of Futures Markets, Quarterly Review of Economics and Finance, Applied Operations Research, Quantitative Finance.

SEMINARS AND CONFERENCE PRESENTATIONS

Presenter, "Dealer Trading at the Fix." December 15, 2017. Second annual Conference on High Frequency Exchange Rate Dynamics: Econophysics and Econometric Analysis Based on the EBS data sets. Tokyo, Japan.

Presenter, "Dealer Trading at the Fix." December 21, 2017. Eurofidai Conference, Paris, France.

Discussant, "Did the Reform Fix the London Fix problem?" By Takatoshi Ito and Masahiro Yamada. March, 2017: International Conference on High Frequency Exchange Rate Dynamics: Econophysics and Econometric Analysis Based on the EBS data sets. Tokyo, Japan

Discussant, "Puzzles in the Tokyo Fixing in the Forex Market: Order Imbalances and Bank Pricing?" By Takatoshi Ito. March, 2017: International Conference on High Frequency Exchange Rate Dynamics: Econophysics and Econometric Analysis Based on the EBS data sets. Tokyo, Japan

Presenter, "Dealer Trading at the Fix." December 2016: 6th Workshop on Financial Determinants of Foreign Exchange Rates, Cass Business School, London

Presenter, "Bank Reserve Management After the Global Financial Crisis," IBS Brown Bag, December, 2016.

Presenter, "Price Discrimination in OTC Markets." November, 2016, Wilfried Laurier University, Ontario, Canada

Presenter, "Dealer Trading at the Fix." October, 2016: Financial Management Association Annual Meetings, Las Vegas

Presenter, “Dealer Trading at the Fix.” October, 2016. OECD, Paris.

Presenter, “Dealer Trading at the Fix” September, 2016: 12th Annual Central Bank Workshop on the Microstructure of Financial Markets, Banque de France, Paris

Presenter, “Dealer Trading at the Fix.” September 2016: Portsmouth-Fordham Conference on Banking and Finance, University of Portsmouth, UK

Presenter, “Dealer Trading at the Fix.” September 2016: Cass Business School, London

Presenter, "Price Discrimination in OTC Markets." September 2016, CFM (Hedge Fund) Paris

Presenter, “Dealer Trading at the Fix.” September 2016: University of Essex Business School, Colchester, England

Discussant, June 2016: “Illiquidity in the stock and FX markets: an investigation of their cross-market dynamics” by Chiara Banti. Women in Microstructure conference, Park City, UT

Presenter, "Price Discrimination in OTC Markets." April, 2016: Eastern Finance Association meetings, Baltimore, MD.

Discussant, "Libor’s Poker." By Jiakai Chen. April, 2016: Eastern Finance Association meetings, Baltimore, MD.

Presenter, "Depth and Information in the Foreign Exchange Limit Order Book: A Nonlinear Approach" (with Ly Tran). June, 2015, Women in Microstructure Conference.

Discussant, “Forex Trading and the WMR Fix,” by Martin D.D. Evans. NYU-Stern Annual Microstructure Meetings, May, 2015.

Discussant, “Understanding FX Liquidity,” Karnaukh, Ranaldo, Soöerlind, 10th Annual Central Bank Workshop on the Microstructure of Financial Markets, Rome, Italy, October 2014.

Presenter, “Asymmetric Information and the Foreign Exchange Trades of Global Custody Banks,” Joint with Tanseli Savaser and Thang Tan Nguyen.” Midwest Finance Association Annual Meeting, New Orleans, February 23, 2012.

Discussant, Mink, Mark, “Procyclical Bank Risk-Taking and the Lender of Last Resort,” DNB Working Paper No. 301 (July 2011). Midwest Finance Association Annual Meeting, New Orleans, February 23, 2012.

Presenter, “Noise Trading and Illusory Correlations in U.S. Equity Markets,” joint with Jennifer Bender and David Simon. Behavioral Finance Working Group Conference, Cass Business School, London. (presented, due to time conflict, by David Simon) April 7, 2011.

Discussant, “Market Reaction to Second-Hand News: Attention Grabbing or Information Dissemination?” Cervellati, Enrico Maria, Riccardo Ferretti, and Pierpaolo Pattitoni (presented by David Simon). April 7, 2011.

Presenter, “Extreme Returns: The Case of Currencies,” joint with Tanseli Savaser. Boston QWAFAFEW, July 2010.

Presenter, “Hedge Funds and the Origins of Private Information in Foreign Exchange Markets,” French Finance Association Meetings, Paris, December 16, 2009.

Presenter, "Uninformed Momentum Traders," Ali Emre Konokoglu, Discussion, French Finance Association Meetings, Paris, December 16, 2009.

Presenter, “Technical Analysis of Equity Indexes,” Warwick Business School, University of Warwick, U.K. December 2, 2009.

Presenter, “Technical Analysis of Equity Indexes,” AFATE, Paris, December 16, 2009.

Presenter, “Technical Analysis of Equity Indexes,” Society of Technical Analysts, London, November 10, 2009.

Presenter, “Overconfidence in Currency Markets,” Cass Business School, London, November 4, 2009.

Presenter, “Exchange-Rate Effect of Multi-Currency Arbitrage,” Harald Hau, Discussion, Sixth Annual Central Bank Workshop on the Microstructure of Financial Markets, Zurich, Switzerland, October 8, 2009.

Presenter, “Hedge Funds and the Origins of Private Information in Foreign Exchange Markets,” Bank for International Settlements, Basel, October 7, 2009.

Presenter, “Extreme Returns Without News: The Case of Currencies,” Financial Economics Research Center Conference on Microstructure, September 23, 2009.

Discussant, "Crash Risk in Currency Markets," Romain Ranciere, Xavier Gabaix, Adrien Verdelhan, Emmanuel Farhi, Discussant, Western Finance Association Meetings, San Diego, June 17-20, 2009.

Presenter, “Hedge Funds and the Origins of Private Information in Foreign Exchange Markets,” Third Annual Microstructure Workshop, Emerging Markets Group, Cass Business School, London, May 1, 2009.

Panelist, “Causes and Consequences of the Financial Crisis,” Jean Beer Center for Ethics, Philosophy Department, Georgia State University, Atlanta, GA, March 18, 2009.

Presenter, “Extreme Returns Without News: The Case of Currencies,” State Street Advanced Research Center, March 11, 2009.

Presenter, “Extreme Returns Without News: The Case of Currencies,” International Federation of Technical Analysts, Paris, November 6-8, 2008.

Presenter, "Extreme Returns Without News: The Case of Currencies," Midwest Finance Association meetings, Dallas, Texas, October 2008.

Presenter, "Short-Run Exchange-Rate Dynamics: Theory and Evidence," Infiniti Conference, Dublin, Ireland, June 2008.

Presenter, "Short-Run Exchange-Rate Dynamics: Theory and Evidence," Seminar at UNH Durham, October, 2007.

Presenter, "Asymmetric Information in the Interdealer Foreign Exchange Market," Joint with Geir Bjønnes and Dagfinn Rime, *Third Annual Conference on Market Microstructure*, Budapest, Hungary, September 15, 2007.

Presenter, "Extreme Returns: The Case of Currencies," joint with Tanseli Savaser. *Third Annual Conference on Market Microstructure*, Budapest, Hungary, September 15, 2007

Presenter, "Price Discovery in Currency Markets," Seminar Presentation at the NBER Conference on Microstructure, May 11, 2007.

Presenter, "Price Discovery in Currency Markets," Seminar Presentation at Acadian Asset Management, April 4, 2007.

Presenter, "Short-Run Exchange-Rate Dynamics: Theory and Evidence," Seminar at Williams College, April 2, 2007.

Presenter, "Price Discovery in Currency Markets," Seminar presentation at Rutgers University, November 28, 2006.

Presenter, "Price Discovery in Currency Markets," Seminar at State Street Global Research Advanced Research Center, December ? 2007.

Presenter, "Short-Run Exchange-Rate Dynamics: Theory and Evidence," seminar presentation at Hannover University, Hannover, Germany, November 15, 2006.

Presenter, "Price Discovery in Currency Markets," seminar presentation at the University of Copenhagen, Copenhagen, Denmark, November 13, 2006.

Presenter, "Price Discovery in Currency Markets," Bank of Canada/Norges Bank Conference on the Microstructure of Equity and Foreign Exchange Markets, Ottawa, Canada. October 20-21, 2006.

Presenter, "Price Discovery in Currency Markets," Seminar presentation at the Federal Reserve Bank of St. Louis, October 4, 2005.

Presenter, "Price Discovery in Currency Markets," Hong Kong Institute for Monetary Research Conference on financial Markets and the Macroeconomy. Hong Kong, July 13-14, 2006.

Presenter, "Price Discovery in Currency Markets," MMF/ESRC/WFRI Workshop on the Micro Structure of FX markets and Fixed Income. Warwick University Business School, Wednesday 28th June 2006.

Presenter, "Macro Lessons from Microstructure," Seminar presentation at University of North Carolina, April 1, 2006.

Presenter, "Macro Lessons from Microstructure," Seminar presentation at the Bank of Canada, April 12, 2006.

Presenter, "Macro Lessons from Microstructure," Seminar presentation at University of Virginia, March 1, 2006.

Presenter, "Getting Tenure," CSWEP Annual Mentoring Conference, Boston, MA, January 10, 2006.

Presenter, "Short-Run Exchange-Rate Dynamics: Theory and Evidence," American Economic Association Annual Meetings, Boston, MA January 8, 2006.

Presenter, "Macro Lessons from Microstructure," Econometric Society Annual Meetings, Boston, MA, January 7, 2006.

Presenter, "Short-Run Exchange-Rate Dynamics: Theory and Evidence," Norges Bank Conference on Equity and Foreign Exchange Microstructure, Oslo, Norway: September 7-8, 2005.

Presenter, "Asymmetric Information and Currency Spreads," Bank of Canada/University of British Columbia Workshop on International Financial Markets, University of British Columbia: August 23-24, 2005.

Presenter, "Asymmetric Information and Currency Spreads," Summer School and Workshop on Market Microstructure, Aix-en-Provence: July 4-8, 2005.

Presenter, "Short-Run Exchange-Rate Dynamics: Theory and Evidence," Seminar presentation at the Federal Reserve Bank of Boston: May 2005.

Presenter, "Stop-Loss Orders and Price Cascades in Currency Markets," Eighth International Conference on International Macroeconomics and Finance, University of Crete, Greece: May 26-28, 2004.

Presenter, "Short-Run Exchange-Rate Dynamics: Theory and Evidence," Seminar at Federal Reserve Bank of Boston May 2004.

Presenter, "Extreme Exchange-Rate Returns Without News: A Microstructural Approach," A series of seminars and private presentations to the customers of the Royal Bank of Scotland in London and New York. Fall 2003 and summer 2004.

Presenter, "Identifying Noise Traders: The Head-and-Shoulders Pattern in U.S. Equities." 4th Empirical Finance Conference, Financial Markets Group, London School of Economics: April 30, 2003.

Presenter, "Stop-Loss Orders and Price Cascades in Currency Markets," Currency Market Microstructure Conference, Stockholm Institute of Finance, Stockholm: April 12, 2003.

Presenter, "Identifying Noise Traders: The Head-and-Shoulders Pattern in U.S. Equities." Conference on Computational Finance, New York, NY, January 1999.

Presenter, "Identifying Noise Traders: The Head-and-Shoulders Pattern in U.S. Equities." Financial Management Association Annual Meetings, New York City, October 1998.

Presenter, "Identifying Noise Traders: The Head-and-Shoulders Pattern in U.S. Equities." Conference on Forecasting Financial Markets sponsored by Imperial College, London, and Banque National de Paris. London, May 27-29, 1998.

Presenter, "Identifying Noise Traders: The Head-and-Shoulders Pattern in U.S. Equities." French Finance Association Annual Meetings, Grenoble, France, June 23-25 1997.

Presenter, "Head-and-Shoulders: Not Just a Flaky Pattern," System Committee on International Economics Fall Meeting, Kansas City, 1995

Presenter, "Head-and-Shoulders: Not Just a Flaky Pattern," Financial Management Association Annual Meetings, New York, New York, October 1995.

Presenter, "Head-and-Shoulders: Not Just a Flaky Pattern," Conference on Forecasting Financial Markets, London, April 1995.

Presenter, "Head-and-Shoulders: Not Just a Flaky Pattern," Eastern Economic Association Meetings, New York, NY, March 1995.

Presenter, "Origins of Near-Random Walk Exchange Rate Behavior," American Economic Association Annual Meeting, Anaheim, California, January 1993.

Presenter, "Origins of Near-Random Walk Exchange Rate Behavior," European Economic Association Annual Meeting, Dublin, Ireland, August 1992.

Presenter, "Origins of Near-Random Walk Exchange Rate Behavior," Eastern Economic Association Annual Meeting, New York, New York, March 1992.